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ACTIVE SONAR TARGET CLASSIFICATION. VOLUME I. EXPERIMENTAL.(U)
JUL 65 R O'NEILL
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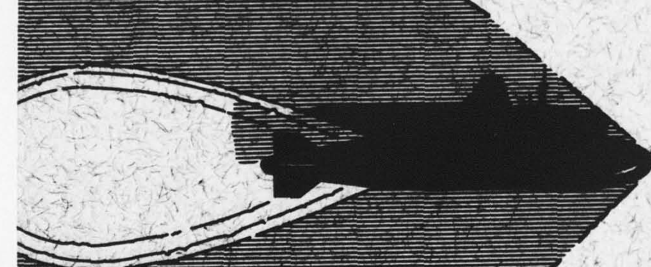
G. S. Innis

REPORT B912
20 JULY 1965

ACTIVE SONAR TARGET CLASSIFICATION (U)

Technical Report

VOLUME I - EXPERIMENTAL



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20 JULY 1965

Technical Rept. 17p.

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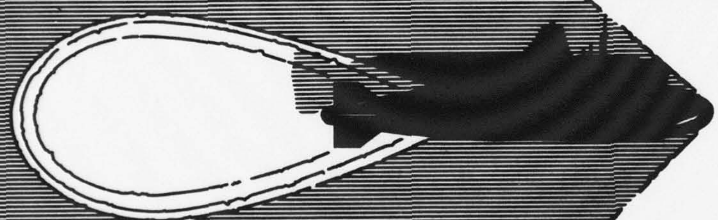

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ABSTRACT

I. INTRODUCTION

The McDonnell Aircraft Corporation, through its Electronic Equipment Division, is pleased to submit this report on the problem of identifying active sonar echoes in response to U. S. Navy Electronics Laboratory letter SF 001 03 16, Task 8132 (NEL Problem E11151) Ser 3180-11, dated 17 June 1965.

This report, Volume I of two volumes, covers the (experimental) examination performed by McDonnell Aircraft Electronics to determine similarities and differences between submarine and non-submarine targets. ABSTRACT

As a criterion for detection, basic doppler shift was ruled out. Many non-submarine targets such as fish, and bottom targets in a current evidence a doppler shift from the reverberation center frequency. Also ruled out was the fact that the submarine target is metal and may exhibit hull resonance. A good example of "smelling the Steel" in the returning pulse (sharp echo, good doppler) was the occasional depth charging of the hull of the Tang in Tsushima Straits during the Korean War.

Since the submarine is the only submerged vehicle propelled by rotating screws, the first conclusion reached was that the way to active sonar target classification might be the wake astern, rather than the target itself. The second assumption made was that the frequency modulation signature due to the wake pulsation and tail-off would be less distorted than the amplitude signature.

Active sonar tapes made from the AN/SQS-26 and the AN/SQS-23 have been evaluated. Section III indicates the mechanization for extracting the first cut information from the taped signals. Equipment refinements are underway to alleviate certain noise problems. Section IV describes the results obtained to date and the feasibility of extracting wake information. The broad frequency signature of the wake from propeller to tail-off have been found for bow and stern aspects. Apparent tape wow and flutter currently mask the details due to rotation and pulsation.

II. WAKE VORTEX

2.1 WAKE VORTEX. The vortex produced in the wake of a submarine by one or more rotating propellers is an extremely complex signature. Writing in the March 1965 issue of Scientific American, F. H. Harlow and J. E. Fromm discuss at some length the computer simulation of the wake produced in a moving fluid by a rectangular bar. This two-dimensional problem is considered to be complicated, and the writers indicate that the necessary mathematical techniques for obtaining the complete solution have not yet been developed. Certain assumptions can be made, however, to develop a qualitative postulation of what occurs, and this postulation can be verified from experimental data.

2.2 ASSUMPTIONS. Some of the assumptions made in describing the wake are:

a) The wake size is significant compared to the submarine.

b) The wake moves at velocities with respect to the surrounding medium which are opposite to the submarine velocity vector and which vary with the distance from the source propeller.

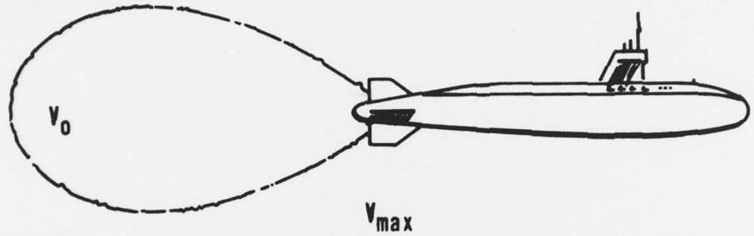
c) The wake diameter varies with the distance from the source propeller.

d) The wake is made up of an interaction between the vortex streets of each blade and between the resultant and the surrounding media.

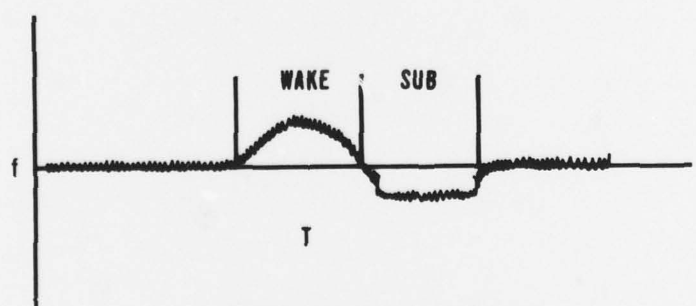
e) The individual vortex street is extremely complex, per Harlow and Fromm.

2.3 DESCRIPTION. Based on the above, a cross-section of the wake along its axis should produce an envelope roughly oval in shape, and moving away from the submarine. The velocity of the wake with reference to the surrounding medium should be in a direction opposite to the submarine, and should decrease to zero as the wake dies out. (Figure 2.1)

Within the wake, areas of turbulence will exist. If the frequency of the returning echo is scanned vs time, and if the target length is large compared to the pulse length, a stern aspect should produce a time frequency plot showing up doppler from the wake followed by down doppler from the submarine. (Figure 2.2.)



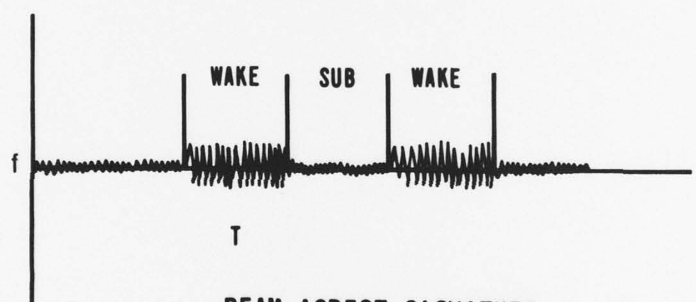
WAKE ENVELOPE
FIGURE 2.1



STERN ASPECT SIGNATURE
FIGURE 2.2

The case of a bow aspect should produce the reverse effect.

For a beam aspect, the effect is not as clear, however, if the assumption that the wake diameter is larger than the submarine is valid. The leading and trailing edges of the echo should contain wake information which is more turbulent than the reverberation, and should produce a characteristic time-frequency plot as in Figure 2.3.



BEAM ASPECT SIGNATURE
FIGURE 2.3

III. MECHANIZATION

The circuits designed to produce an output proportional to a frequency sweep about 3.5 Kc are shown in block diagram from Figure 3.1.

The first six blocks are pulse shaping circuits that prepare the uncorrelated input for processing in the quadrature frequency detector. The detector requires a constant amplitude signal for proper operation which is provided by the compressor circuit just previous to the detector input. The frequency detector is designed to provide amplitude variation cancellation so that only frequency shift is detected with a sensitivity of 12 millivolts per cycle. A detailed report of this detector was submitted to BuShips as a progress report (McDonnell Report 456) on 1 June 1965.

These circuits were originally designed for processing the SQS-26 signals at 3.5 Kc. In order to process the SQS-23 data tapes, supplied by BuShips, the 18 Kc signal was heterodyned down to 3.5 Kc. The output of the detector was fed to one input of a dual beam scope and the amplitude

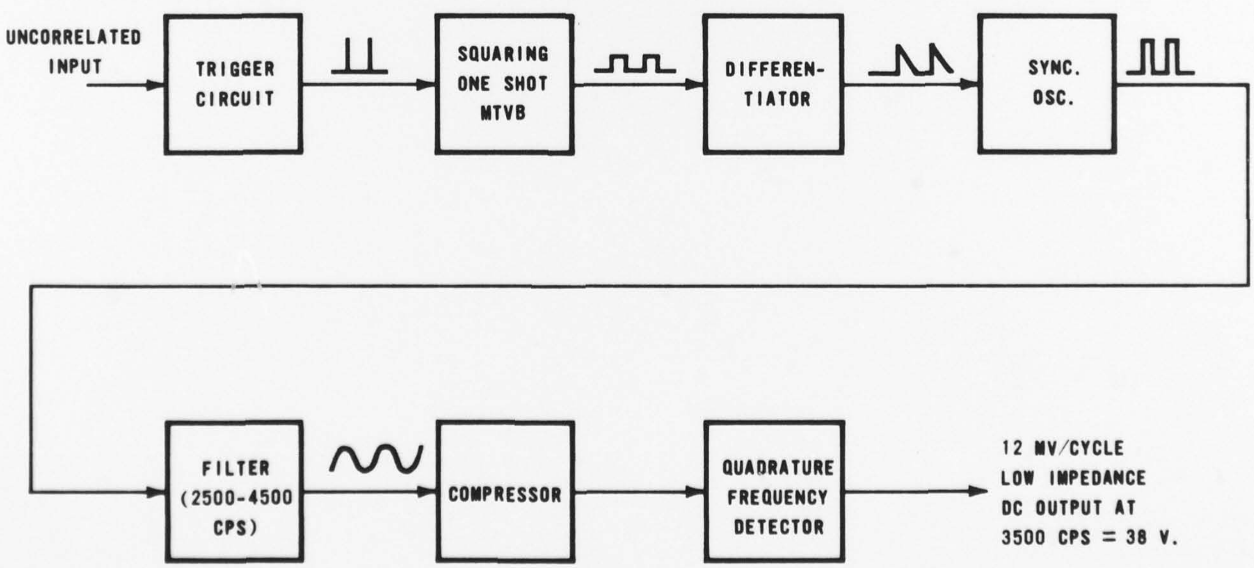


FIGURE 3.1

TARGET ECHO PROCESSING
BLOCK DIAGRAM

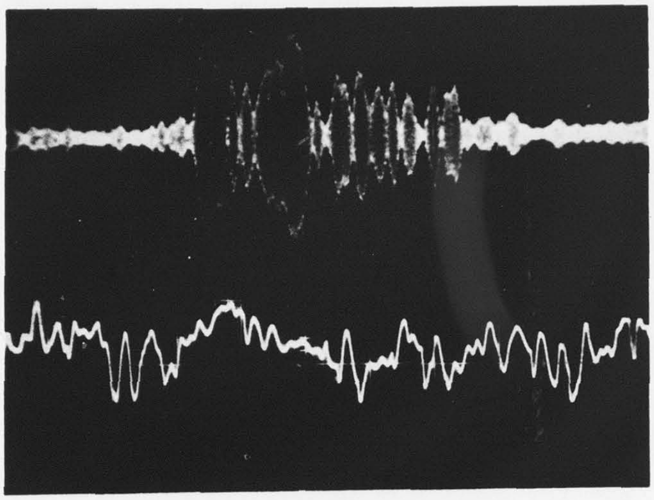
information was displayed on the viewing screen at the same time that the frequency information was displayed. A polaroid picture was then taken of this display. In locating the echo by amplitude and checking the second channel, the frequency characteristic could be observed.

IV. RESULTS

4.1 FIRST PHASE. The first phase of the study is to determine experimentally the feasibility of detecting the wake itself. For this purpose the AN/SQS-23 tapes were used. Each echo is photographed on a dual trace scope. The upper trace is unrectified amplitude and the lower trace is the time-frequency history. The circuitry used to develop the time-frequency history eliminates all amplitude variations. Initial trials indicated considerable frequency noise, and as a consequence the same pulse was viewed using two tape machines (SP 300 and FR 1300). Visual correlation of the two pictures indicated that the noise was not flutter and wow from the playback units. The general signatures for bow and stern aspects were as expected and it was possible for untrained persons to identify the aspect from the photos. It was also possible to differentiate bow and stern aspect targets from beam and non-sub targets.

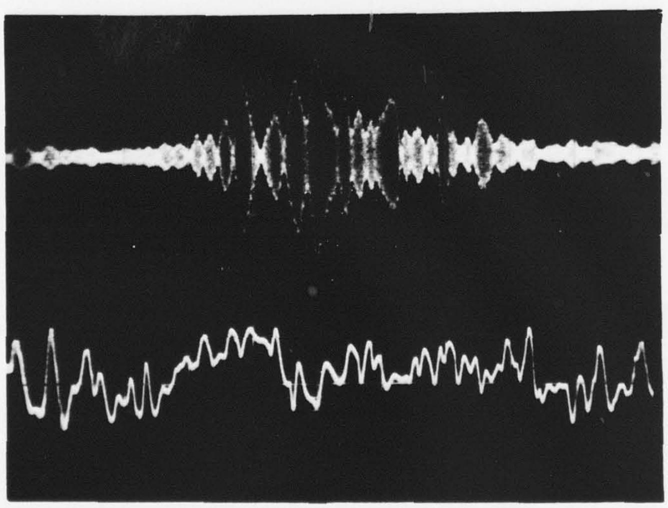
Figure 4.1 (a), (b) and (c) typify the echoes from a stern aspect. Figure 4.1 (d), (e) and (f) show bow aspects. Figure 4.2 (a), (b) and (c) show typical non-sub echoes. In general, it can be seen that the stern aspect produces a small up doppler followed by the main hull doppler, and the bow aspect produces the reverse effect.

4.2 NEXT PHASE. The next phase of the study will concentrate on noise elimination to determine if the low frequency wake doppler due to the internal turbulence can be determined. Additionally, a power spectral density examination is being performed using an IBM 7094 computer.



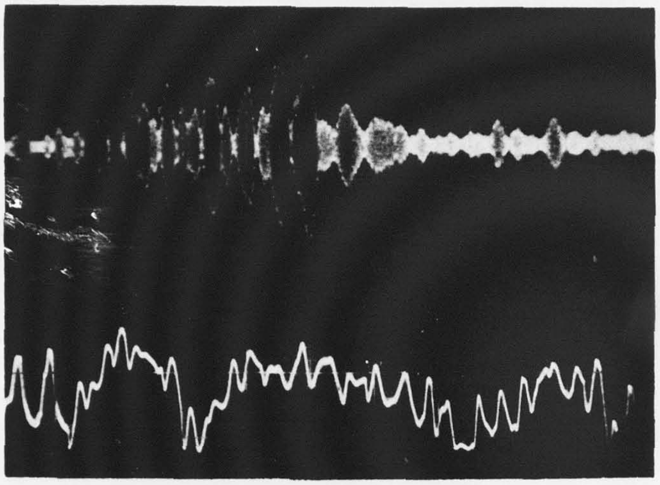
REEL NO.3, SEG.1 (SHORT); PING NO.4;
SWEEP TIME 20 MS/CM; STERN.

FIGURE 4.1 (a)



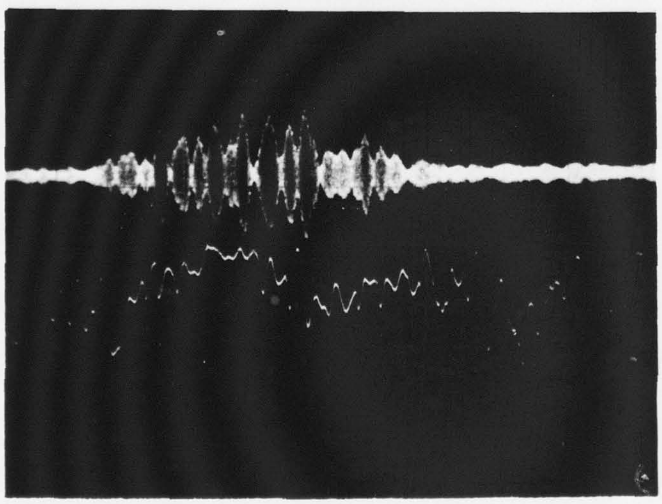
REEL NO.3, SEG.1 (SHORT); PING NO.26;
SWEEP TIME 20 MS/CM; STERN

FIGURE 4.1 (b)



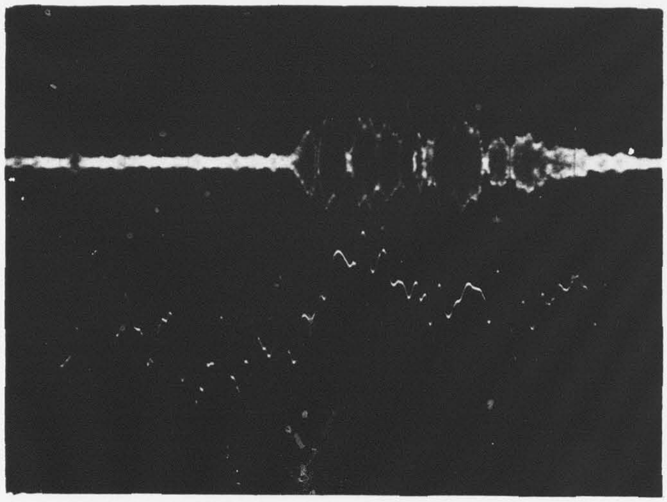
REEL NO.3, SEG.1 (SHORT); SWEEP TIME 20 MS/CM; PING NO.21; STERN.

FIGURE 4.1 (c)



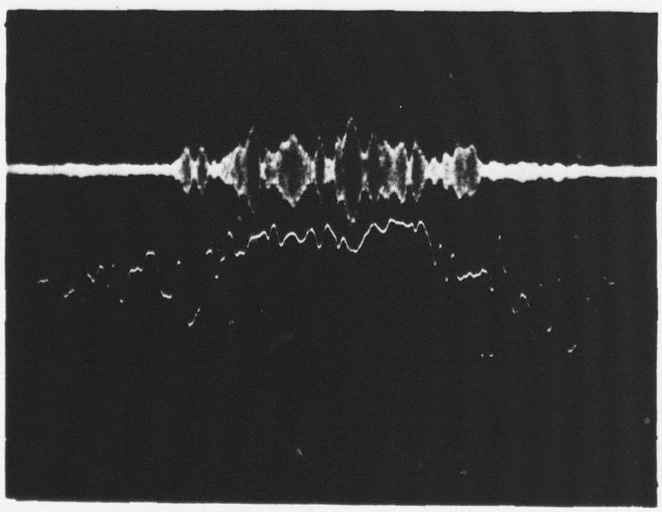
REEL NO.3, SEG.6 (SHORT); PING NO.13; SWEEP TIME 20 MS/CM; BOW.

FIGURE 4.1 (d)



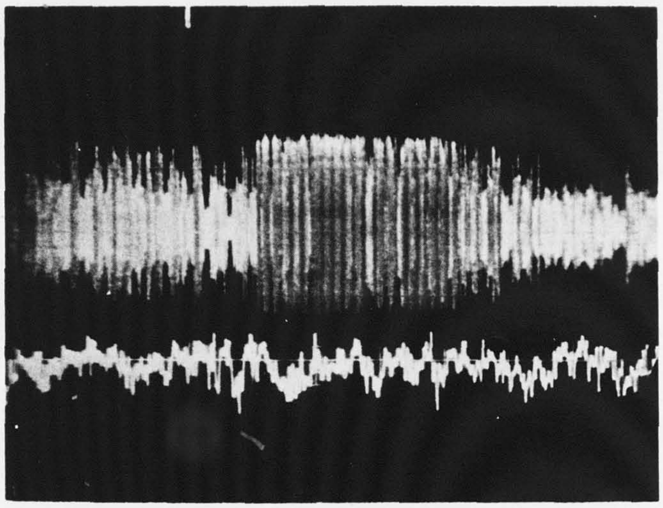
REEL NO.3, SEG.6 (SHORT); PING NO.27;
SWEEP TIME 20 MS/CM; BOW.

FIGURE 4.1 (e)



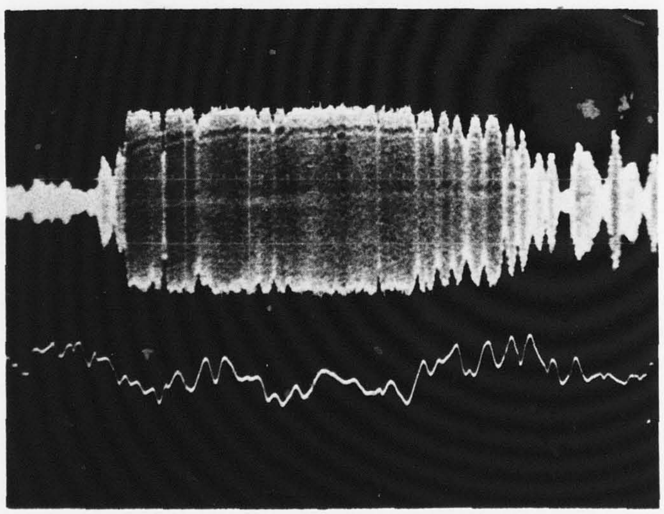
REEL NO.3, SEG.6 (SHORT); PING NO.48;
SWEEP TIME 20 MS/CM; BOW.

FIGURE 4.1 (f)



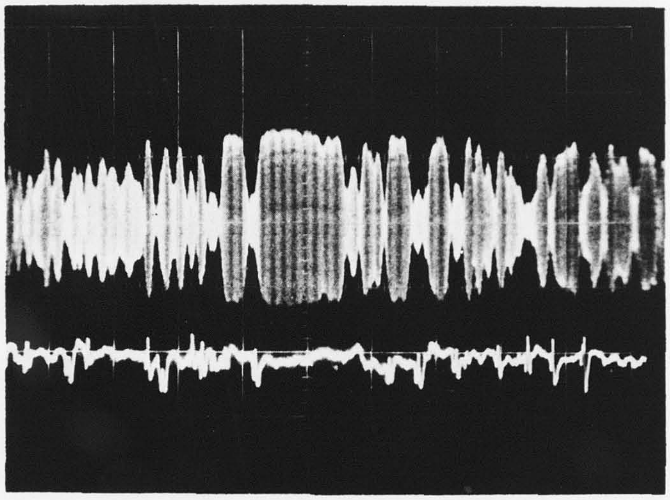
REEL NO.16; PING NO.80 (APPROX) (SHORT); RG.2.5 KYDS 0960; NON-SUB; SWEEP TIME .1 S/CM.

FIGURE 4.2 (a)



REEL NO.16, SEG.1; PING NO.7 (SHORT); RG.2.4 KYDS 329°; NON-SUB; SWEEP TIME 20 MS/CM.

FIGURE 4.2 (b)



REEL NO.16; PING NO.10 (APPROX); SEG.2 (MEDIUM); RG.2.9 KYDS 014°-049°; NON-SUB; SWEEP TIME .1 SEC/CM.

FIGURE 4.2 (c)